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Patent claims and economic growth

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ABSTRACT

This study introduces a blocking patent on horizontal R&D into the endogenous growth model of Chu et al. (2012), which features a blocking patent on vertical R&D. Results show that strengthening patent protection on horizontal R&D promotes vertical innovation (quality improvement) but hinders horizontal innovation (variety expansion). This effect of a horizontal blocking patent on directionality of innovation is opposite to that of the vertical blocking patent analyzed by Chu et al. (2012). Results also show that under mild conditions, strengthening a blocking patent on horizontal innovation as well as on vertical innovation can increase economic growth and social welfare.

1. Introduction

According to the traditional interpretation, patent protection promotes technological progress by preventing imitation, thereby increasing innovations. However, issues arise concerning the extent of protection and the strategic approach to obtain a patent called a blocking patent.[1] In circumstances involving sequential innovation, firms access previously patented products, processes, or technologies for a new innovation. Therefore, they must share their profits with holders of the original patent for patent infringement.[2] This formulation of the profit-division rule implies that strengthening patent protection strengthens the rights of patent holders and enlarges their payments from others wishing to apply their patents. As a result, strengthening patent protection could inhibit subsequent innovation because it ereduces incentives to engage in R&D. A patent that gives rise to these consequences is called a blocking patent because it potentially "blocks" future innovations. This study introduces a blocking patent on horizontal R&D (activities for variety expansion that result in new industries) into the model proposed by Chu et al. (2012), which features a blocking patent on vertical R&D (activities for quality improvement within an industry). It then analyzes how these two types of blocking patents affect directionality of innovation and economic growth.

Many studies analyze whether strengthening patent protections promotes economic growth.[3] Typical patent policy instruments examined in the patent design literature are patent length,[4] patentability requirements, and patent breadth.[5] This paper investigates the last. Two types of patent breadth are relevant to sequential innovations: lagging breadth sets the extent of patent protection against imitation,[6] and leading breadth provides protection against future innovations. O'Donoghue and Zweimüller (2004) analyze the effects of patentability requirements and leading breadth on economic growth along the lines of Grossman and Helpman (1991). With a leading patent, a new inventor must transfer his or her profits to the former inventors for infringing on their patents in accordance with predetermined profit-division rules. Effects of a blocking patent on economic growth have been analyzed by Chu (2009); Chu et al. (2012); Chu and Pan (2013), and Cozzi and Galli (2014). Developing a simple R&D-based growth model that includes quality improvements and variety expansion,[7] Chu et al. (2012) apply a profit-division rule to vertical R&D and analyze how a blocking patent within an industry affects directionality of innovation.

Although most previous studies analyze relations between patent protections and rates of innovation, Chu et al. (2012) examine how a blocking patent as a policy variable changes the directionality of innovation. Their approach has another merit: by specifying patent protection as a profit-division rule rather than as a markup effect,[8] the economic mechanism behind the obtained results can be understood through a simpler model. Their model, however, considers only vertical blocking patents, and in reality, horizontal and vertical innovations are both

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[1] See Shapiro (2001).

[2] An increase in the share of the profit for patent infringement can be considered an increase in the licensing fee for broader patent breadth when patent protection strengthens.

[3] Azebedo et al. (2014) analyze relations between intellectual property rights and economic growth in a north–south endogenous growth model.

[4] See Chu (2010); Iwaisako and Futagami (2003), and Futagami and Iwaisako (2007).

[5] See Iwaisako and Futagami (2013).

[6] See Horii and Iwaisako (2007) and Furukawa (2007).

[7] See Oura and Morita (2013) for an endogenous variety expansion model.

[8] Chu (2011) and Chu and Furukawa (2011) treat patent breadth as a markup effect.

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highly correlated. Thus, it is important to analyze effects of horizontal blocking patents along with vertical blocking patents.[9]

A patent in the horizontal R&D can be interpreted as a licensing agreement between the new inventor and the patent holders of different industries.[10] There are many instances of firms patenting technologies or processes and licensing them to firms in their industry or elsewhere for adaptation to different products. For instance, laser technology as a new invention was not initially intended for commercial application, but it has been adopted in medical technology (notably ophthalmology), information and communication technology, and many other industries and products. As another example, biotechnology is applied to the medical field, food, agriculture, and the environment. In some cases, a blocking patent can be observed and the extent of patent protections for basic technology has been debated in trials because broad patents can delay or prevent basic technologies from being applied in wide range of areas.[11] One of the most famous examples is Oncomouse.[12]

As seen above, blocking patents affect not only vertical innovations but also horizontal innovations, and models that examine the consequences of strengthening protections must include both in order to analyze the optimal patent system in economic terms. This study takes that approach. Results indicate that strengthening a blocking patent on vertical R&D promotes horizontal innovation but slows vertical innovation. Conversely, strengthening a blocking patent on horizontal R&D promotes vertical innovation and slows horizontal innovation. Results also reveal that economic growth and social welfare are maximized by use of the two types of blocking patents under mild conditions.

This paper proceeds as follows. Section 2 constructs an R&D-based growth model featuring two blocking patents. Section 3 defines equilibrium conditions. Sections 4 and 5 discuss effects on economic growth and welfare. Section 6 concludes.

2. Model

Apart from introducing a patent that blocks horizontal R&D, this model follows Chu et al. (2012) in construction and notation. Accordingly, I hold explanations of the model to a minimum and present few details about derivations and interpretations of equations. On vertical R&D, the subsequent innovation intrudes upon an existing patent and the most recent innovator must share a fraction $s\in[0,1]$ of his or her profits with the previous innovator. On horizontal R&D, new inventors intrude upon all patents held by the most recent innovators in creating a new good. In this latter case, the new inventor pays patent holders a fraction $\beta\in[0,1]$ of his or her profits for infringement.

2.1. Households

A continuum of homogenous households with size normalized to 1 is assumed. Their utility function is specified by $U=\int_0^{\infty}e^{-\rho t}\ln c_t dt$, where $c_t \equiv exp(\int_0^{n_t^*}\ln y_t(i)di)$. The process of variety n_t^* is specified as $\dot{n}_t^*=\dot{n}_t-\delta n_t^*$. The household budget constraint is $\dot{a}_t=r_t a_t+w_{h,t}+w_{l,t}L-\int_0^{n_t^*}p_t(i)y_t(i)di$, where a_t represents household assets and r_t is the interest rate. Households supply one unit of skilled labor for R&D and $L>1$ units of unskilled labor for production. $w_{h,t}$ and $w_{l,t}$ denote their respective wages. $p_t(i)$ denotes the price of product i at time t. Household optimization follows two equations—$p_t(i)y_t(i)=1/\zeta_t$ and $r_t=\rho-\dot{\zeta}_t/\zeta_t$—where ζ_t denotes the Hamiltonian co-state variable.

[9] Eswaran and Gallini (1996) emphasize that analyzing the effects of patent policy requires the consideration of both horizontal innovation (product innovation) and vertical innovation (process innovation).

[10] Following Aghion and Howitt (1996), horizontal and vertical R&D can be considered as basic and applied research.

[11] Ko (1992) analyzes the scope of patent and technological progress in biotechnology based on examples of cases.

[12] See Kelves (2002).

2.2. Production

The most recent innovator in each industry employs unskilled labor in production. The production function in industry i is $y_t(i)=z^{q_t(i)}l_t(i)$, and the marginal cost of production for the most recent innovator is $mc_t(i)=w_{l,t}/z^{q_t(i)}$. The previous innovator and the most recent innovator are under Bertrand competition. The price for the most recent innovator is $p_t(i)=z(w_{l,t}/z^{q_t(i)})$. Therefore, the monopolistic profit that the most recent innovator obtains is $\pi_t(i)=(z-1)w_{l,t}l_t(i)=\left(\frac{z-1}{z}\right)\frac{1}{\zeta_t}$.

2.3. Vertical innovation

The no-arbitrage conditions for the previous innovator and for the most recent innovator are, respectively,

$$r_t v_{2,t}=s\pi_t+\dot{v}_{2,t}-(\delta+\lambda_t)v_{2,t}, \tag{1}$$

$$r_t v_{1,t}=(1-s)\pi_t+\dot{v}_{1,t}-(\delta+\lambda_t)v_{1,t}+\lambda_t v_{2,t}+\frac{\beta\pi_t}{n_t^*}. \tag{2}$$

The left sides of Eqs. (1) and (2) denote the return on assets. The first right-hand terms in (1) and (2) denote the profit share between the previous innovator and the most recent innovator. The second terms denote capital gains. The third terms are expected capital losses through obsolescence ($\delta v_{2,t}$ and $\delta v_{1,t}$) and the loss resulting from creative destruction by the subsequent innovation ($\lambda_t v_{2,t}$ and $\lambda_t v_{1,t}$), where λ_t is the probability of innovation.

In Eq. (2), the most recent innovator loses $v_{1,t}$ with probability λ_t but immediately becomes a previous innovator and obtains $v_{2,t}$. Its net expected capital loss then becomes $\lambda_t(v_{1,t}-v_{2,t})$. The last term is the profit share from the new inventor of the horizontal R&D. In cases of horizontal innovation, the firm uses all patents held by the most recent innovators to create a new variety. Therefore, the firm must transfer profits $\frac{\beta\pi_t}{n_t^*}$ to each the most recent innovators of other industries.

There is a continuum of vertical R&D firms whose size is normalized to 1. Their index is given by $j\in[0,1]$ in each industry i. Firm j employs skilled labor $h_{q,t}(j)$. The profit of firm j is $\pi_{q,t}(j)=v_{1,t}\lambda_t(j)-w_{h,t}h_{q,t}(j)$. The arrival rate of innovation measured at the firm level is $\lambda_t(j)=\overline{\varphi}_{q,t}h_{q,t}(j)$. The free-entry condition for vertical R&D is $v_{1,t}\overline{\varphi}_{q,t}=w_{h,t}$, where $\overline{\varphi}_{q,t}=\varphi_q(h_{q,t})^{\phi_q-1}$. $\varphi_q>0$ is the productivity parameter, and $\phi_q\in(0,1)$ denotes the duplication of innovation as a negative externality in each industry. Each industry has an aggregate arrival rate of vertical innovation, represented as $\lambda_t=\varphi_q(h_{q,t})^{\phi_q}$.

2.4. Horizontal innovation

The no-arbitrage condition for $v_{n,t}$ is

$$r_t v_{n,t}=(1-\beta)\pi_t+\dot{v}_{n,t}-(\delta+\lambda_t)v_{n,t}+\lambda_t v_{2,t}. \tag{3}$$

For simplicity, assume a continuum of horizontal R&D firms whose size is normalized to 1 and are indexed using $k\in[0,1]$. The first right-hand term in Eq. (3) denotes the profit share from the new inventor to the most recent innovators. Firms employ skilled labor $h_{n,t}(k)$. The profit of firm k is $\pi_{n,t}(k)=v_{n,t}\dot{n}_t(k)-w_{h,t}h_{n,t}(k)$. Firm k invents new varieties according to $\dot{n}_t(k)=\overline{\varphi}_{n,t}h_{n,t}(k)$. The free-entry condition for horizontal R&D is $v_{n,t}\overline{\varphi}_{n,t}=w_{h,t}$, where $\overline{\varphi}_{n,t}=\varphi_n(h_{n,t})^{\phi_n-1}$. $\varphi_n>0$ is the productivity parameter for horizontal R&D, and $\phi_n\in(0,1)$ denotes the duplication of creating new varieties with an externality. At time t, the sum of the varieties created at the aggregate level is $\dot{n}_t=\varphi_n(h_{n,t})^{\phi_n}$.